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SPAZIO SENZA FRONTIERE:
UN MONDO PIÙ GRANDE È POSSIBILE!

Hypersonic flight for access to Space: basic concepts, historical evolution and hypothesis for an efficient development roadmap

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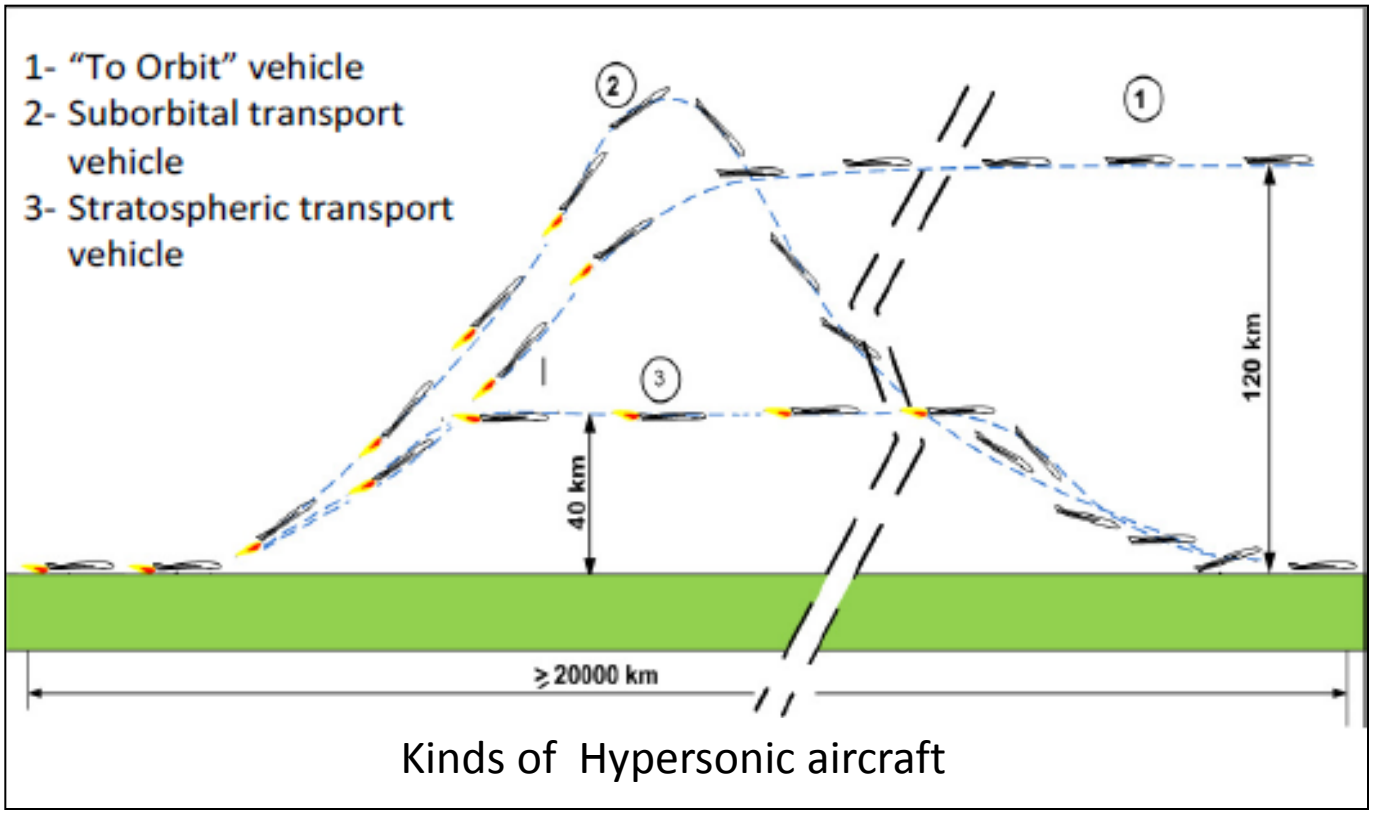
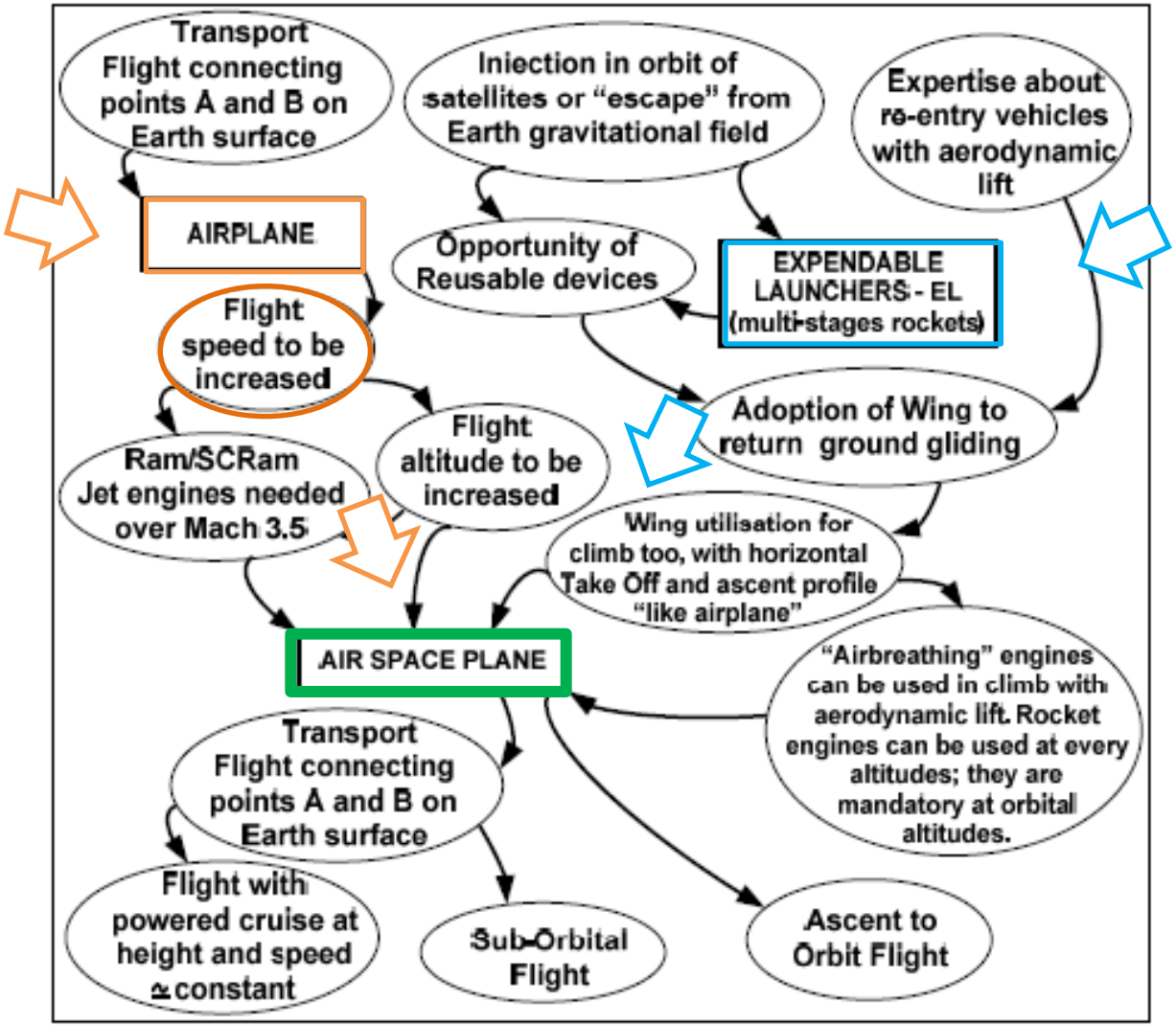
Basic on Hypersonic



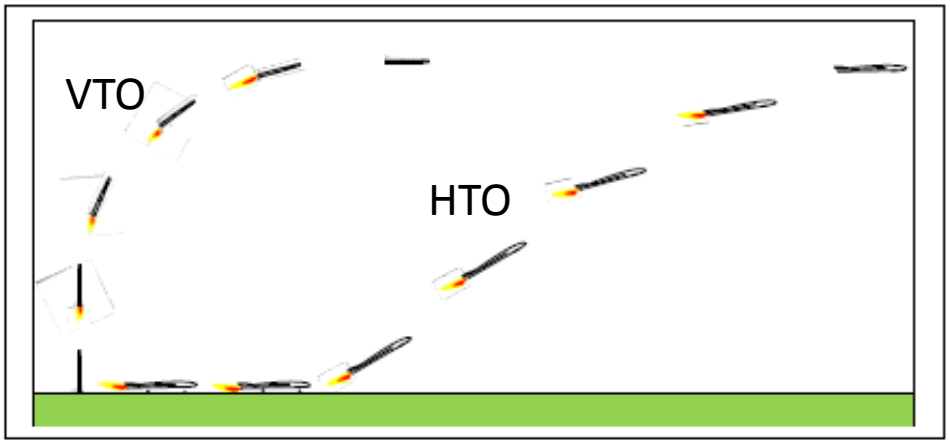
Kinds of Hypersonic aircraft

Hypersonic transport aircraft: HOTOL capability, Mach higher than 4.5 and range greater than 20000 km

Logic path to define Hypersonic Vehicles typologies



Propulsion for Hypersonic Transport Aircraft



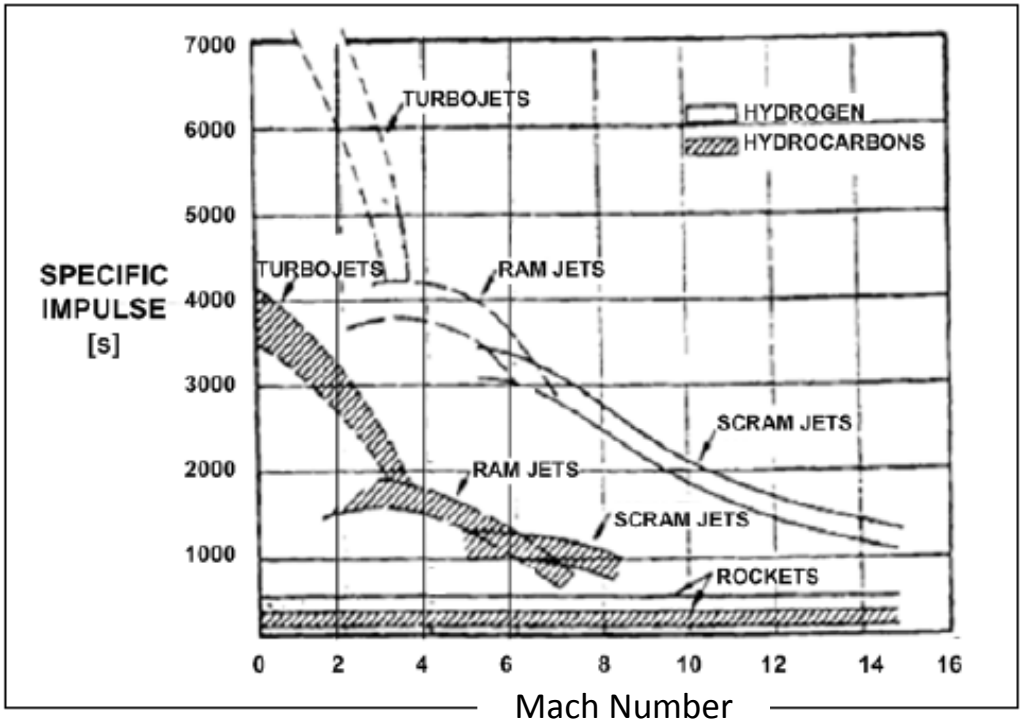
•VTO and HTO Systems ascent trajectories comparison

•HTO flights for more time in the dense layer of atmosphere → "air-breathing " engine

•"air-breathing" engine vs. rocket

Pros: greater specific impulse
Cons: RAM and SCRAM jet cannot provide thrust from speed = 0

•Significant increment of Specific Impulse when LH2 is used

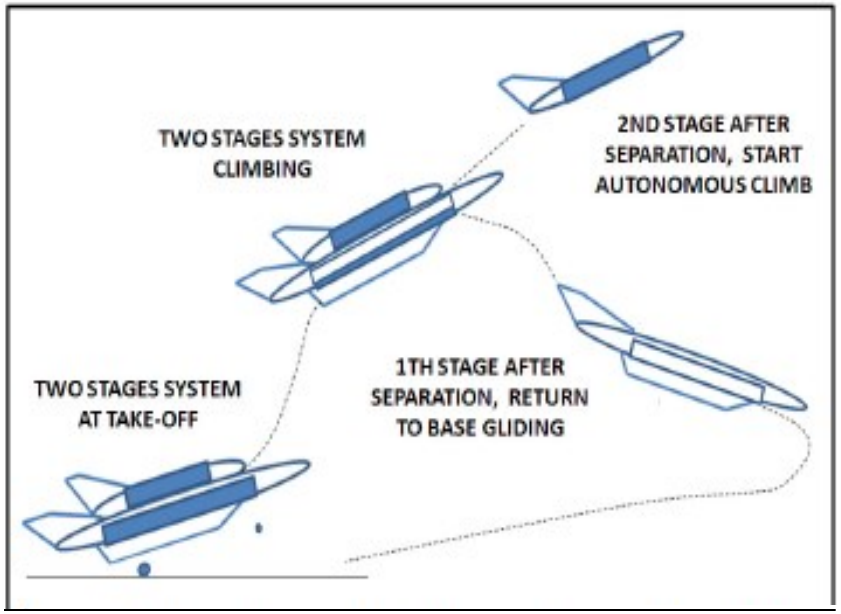


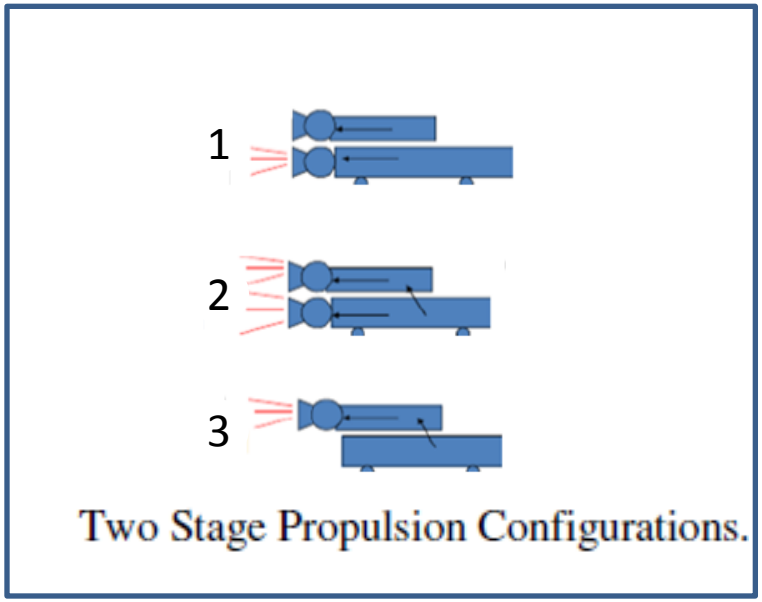
Different propulsion sequence for Hypersonic Planes

TURBOJET with A.B.	RAM JET			Limited to Mach 6. Typical solution for stratospheric cruise airplanes. Turbojet and Ramjet separated or integrated.
TURBO FAN.	ROCKET	RAM JET		As in previous case but with engines more eco-friendly for low altitude phases of flight. Rocket needed to reach ignition speed of Ramjet.
TURBOJET with A.B.	RAM JET	SCRAM JET		Technology still to be examined in depth. Altitude and speed achievable still to be defined.
TURBOJET with A.B.	RAM JET	SCRAM JET	ROCKET	Orbit achievable. Optimal Engines sequence. System complexity.
TURBOJET with A.B.	RAM JET	ROCKET		As previous case, but avoiding Technology not totally acquired yet.
ROCKET	RAM JET	ROCKET		Orbit achievable. Simple System but high consumption.
ROCKET				Simple System, but very high consumption to orbit; more useful for SubOrbital flights.

Stratospheric transport vehicle

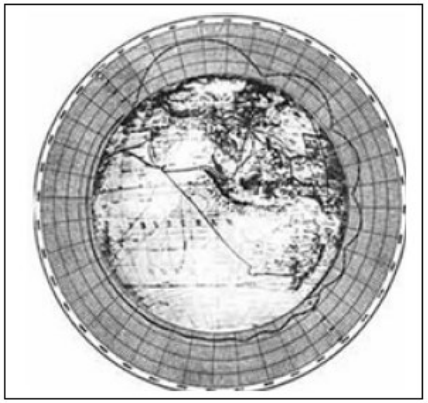
"to orbit" or Suborbital vehicle



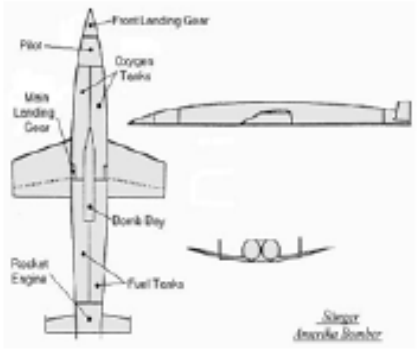


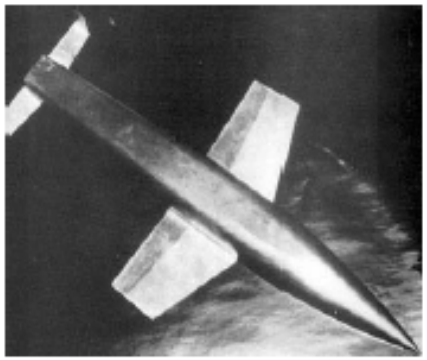
Two Stage Propulsion Configurations.

Overview of Hypersonic planes project



Hypersonic: History

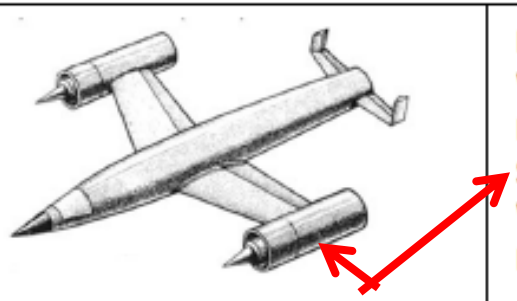




SINGLE STAGE SUB-ORBITAL
Wing Span: 15 m
Length: 28 m
Empty Weight: 10-12 tons
TOGW: 100 – 130 tons
Thrust: 100 tons
Time of Propulsion: 270 – 480 s
Maximum Speed: 22000 km/h
Maximum Altitude: 145 – 280 km
Range: 20000 – 30000 km

Sanger(mid 30's)
Sub-orbital
Rocket powered

Sanger Sub-Orbital BomberConfiguration – Aerodynamic model – Technical Data

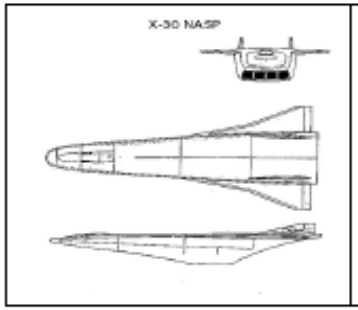


Length: 28 m
Wingspan: 15 m
Propulsion: RDKS-100 (100 ton thrust liquid rocket)
Sustainer: 2x RNII wing-tip ramjets
Weight: 100 tons
Range: 12000 km

After WWII
Stratospheric Hyp.
Rocket and RAM
Jet powered

Soviet Antipodal Bomber; configuration and Technical Data

80's and 90's Hypersonic Aircraft Projects



AirSpacePlane SSTO
Wing Span: 22,6 m
Length: 48,8 m
Empty Weight: 60.000 kg
TOGW: 140.000 kg
Thrust:(RAM/SCRAM Jet) 140.000kg
Propellants: Air/Slush H2
Maximum Speed 26.830 km/h

NASP X 30 Three views drawing, Pictorial representation, Technical Data

SSTO and Hyp. Transp.
Propulsion sequence:
TJ+A/B – RAM J – SCRAM J

AirSpacePlane SSTO
Wing Span: 28,3 m
Length: 63 m
Empty Weight: 50000 kg
TOGW 250000 kg
Pay Load: 7000 kg
Thrust: 110000 kg
Propellants: Air/Slush H2/LOX
Maximum speed: Mach 25,2

HOTOL Three views drawing, Pictorial representation, Technical Data

SSTO
Propulsion RR RB 545 ("air-breather" and Rocket above M 6.5)

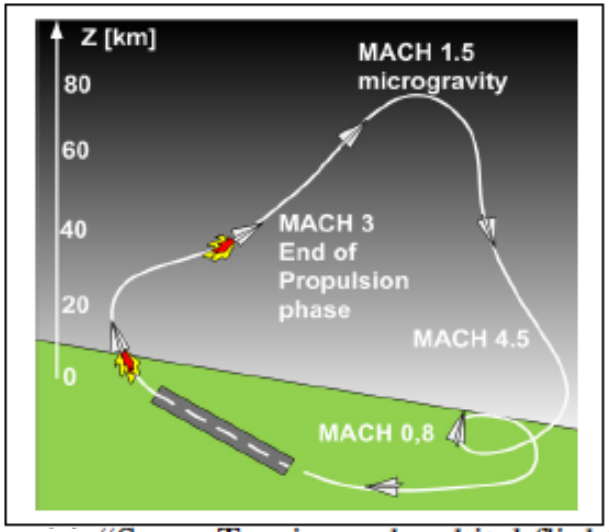
Sänger II 1th Stage
Length: 84.5 m
Diameter: 14.0 m
Span: 41.4 m
Gross mass: 249,000 kg
Empty mass: 149,000 kg
Propellant mass: 95,000 kg
Engines: 5xCo-axial turboramjet
Sea-level thrust: 5 x 300 kN
Propellants: Air/LH2
Burn time: 6,565 s
Maximum speed: Mach 6.8

Sänger II 2nd Stage "manned"
Length: 27.6 m
Diameter: 5.5 m
Span: 15.6 m
Gross mass: 96,000 kg
Empty mass: 23,100 kg
Propellant mass: 69,600 kg
Payload: 6,000 kg to LEO;
Engines: 1 x ATCRE (ATC-700)
Vacuum thrust: 1,280 kN
Propellants: Lox/LHBurn time: 298 s

Sanger II Pictorial representation, Technical Data

TSTO
1st stage: TurboRamJet
2nd stage: Rocket

Space Tourism



"Space Tourism sub-orbital flight.

- The aircraft passenger as space tourist
- "Minimal" space mission profile (sub-orbital flight)
- Small space aircraft (few passengers)

Bristol Spaceplanes Ltd.

Ship Name: Ascender (UK)
Propulsion: 2 Jet and 2 Rocket
Thrust 2 x 500 kg – 2 x 2500 kg
Empty Weight: 2400kg
TO Weight 5500 kg
Launch: Conventional Runway
Landing: Conventional Runway

Fundamental Technology Systems

Ship Name: Aurora (USA)
Propulsion: 1 Variable Thrust – Liquid Rocket
Thrust: 4500 kg
Empty Weight: 5700 kg
TO Weight: 11800kg
Launch: Horizontal from Land
Landing: Horizontal on Land

PanAero, Inc.

Ship Name: SabreRocket (USA)
Propulsion: 2 jet and 7 Rocket
Thrust 2 x 1450 kg – 7 x 2300 kg
Empty Weight: 5700 kg
TO Weight: 11800 kg
Launch: conventional runway
Landing: conventional runway

XCOR Lynx

Ship Name Lynx (USA)
Propulsion: 4 Rocket
Thrust 4 x 1320 kg
Empty Weight: ? kg
TO Weight: 5000 kg
Launch: conventional runway
Landing: conventional runway

Sub-orbital Vehicles for Space Tourism

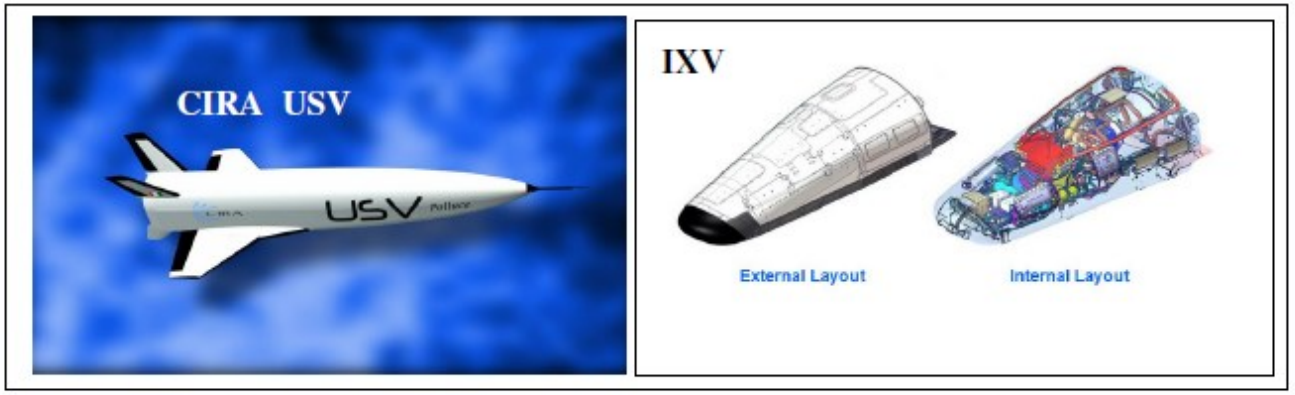
SPACE SHIP TWO	WHITE KNIGHT TWO
Crew: 2	Crew: 2
Capacity: 6 passengers	Payload: 17,000kg at 15,000m
Lenght: 18.29 m	Lenght: 24 m
Wing span: 8.23 m	Wing span: 43 m
Height: 4.57 m	Powerplant: 4 ×P.& W. Canada PW308 turbofan
Powerplant: : 1 x Hybrid Rocket	Thrust: 30.69 kN x 4
Max. altitude: 107 km	Max. altitude: 21,000 m
Max. speed: Mach 4	

Space Ship Two & White Knight Two

- X-Prize Competition (First efficient space tourism aircraft)
  3 passengers
  100 km altitude
  Re-usable
  2 missions in 2 weeks

- Winner:
  Space Ship One (2nd stage rocket powered)
  White Knight One (Subsonic 1st stage)

Reentry Demonstrators from Italy



Italy-led Reentry Vehicles Demonstrators

•Conceived to perform the most critical mission phase:
Re-entry from orbit

ESA PRIDE ISV Reusable Reentry Demonstrator

•ESA PRIDE-ISV start from CIRA USV and IXV experience

SKYLON
Crew: None, remote controlled from ground.
Capacity: Potential for up to 30 passengers
Payload: 15.000 kg (33,000 lb)
Length: 70 m
Wingspan: 22 m
Fuselage diameter: 6.75 m
Empty weight: 53.000 kg
Loaded weight: 345.000 kg
Powerplant: 2 × SABRE 1,350 kN eachThrust/weight: ~1.2 – 3 at burnout (~0.768 atmospheric)
Specific impulse: 3500 s atmospheric, 450 s exoatmospheric
Service ceiling: 26.000 m air breathing, >200 km exoatmospheric
Maximum speed: Orbital (airbreathing Mach 5.5)

SKYLON Pictorial representation, Technical Data

SSTO
Derived from HOTOL
2x SABRE engine
("air-breather" and Rocket)

Hypersonic: the future

Hypersonic Transport
Passengers (300 pax)
Mach 5
"Antipodal" range

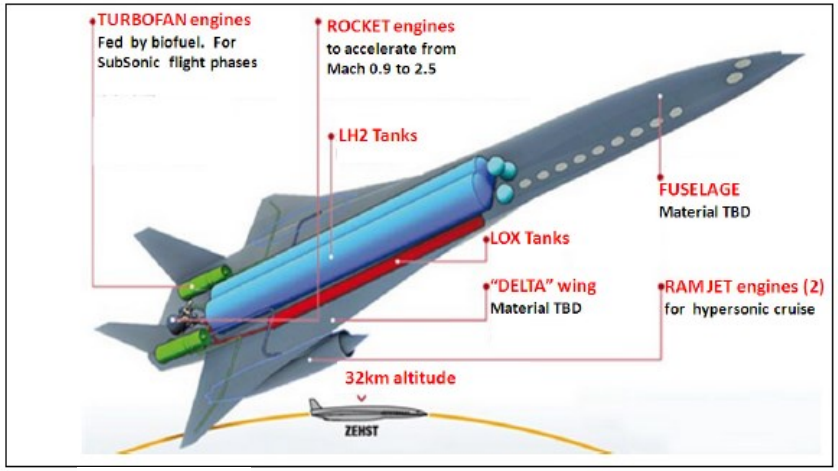
LAPCAT A2

Type: hypersonic passengers transport	
Pax n°	300
Length	139 m
Wing span	41 m
Wing area	900 m²
Take Off Gross Weight	400.000 kg
Fuel Weight	198.000 kg
Engines	4 Scimitar Cruise
Speed	Mach 5
Range	18700 km
Unit cost (estimated)	639 MC

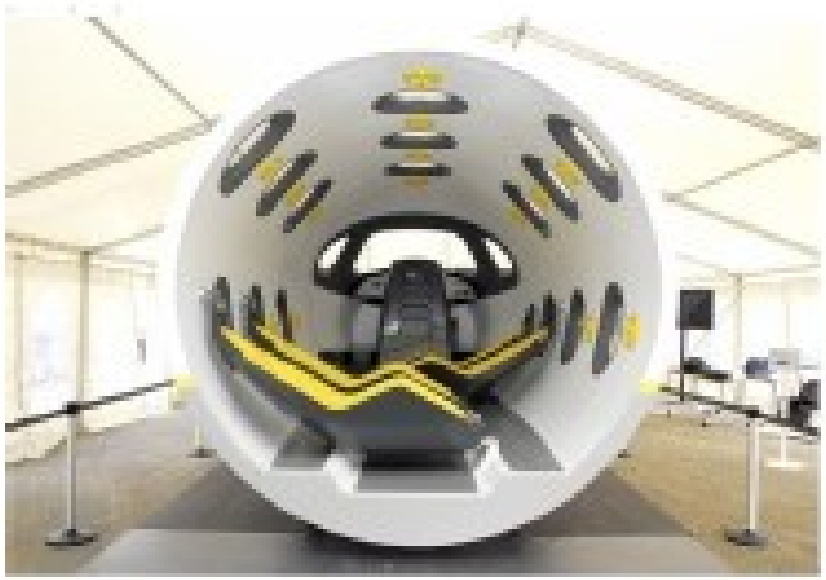
A2 LAPCAT, Pictorial representation, Technical Data

EADS ZEHST-Zero Emissions HyperSonicTransport

Hypersonic Transport
Passengers (60 pax)
Engine sequence:
Turbofan (bio fuel)
Rocket
Ramjet (LH2)



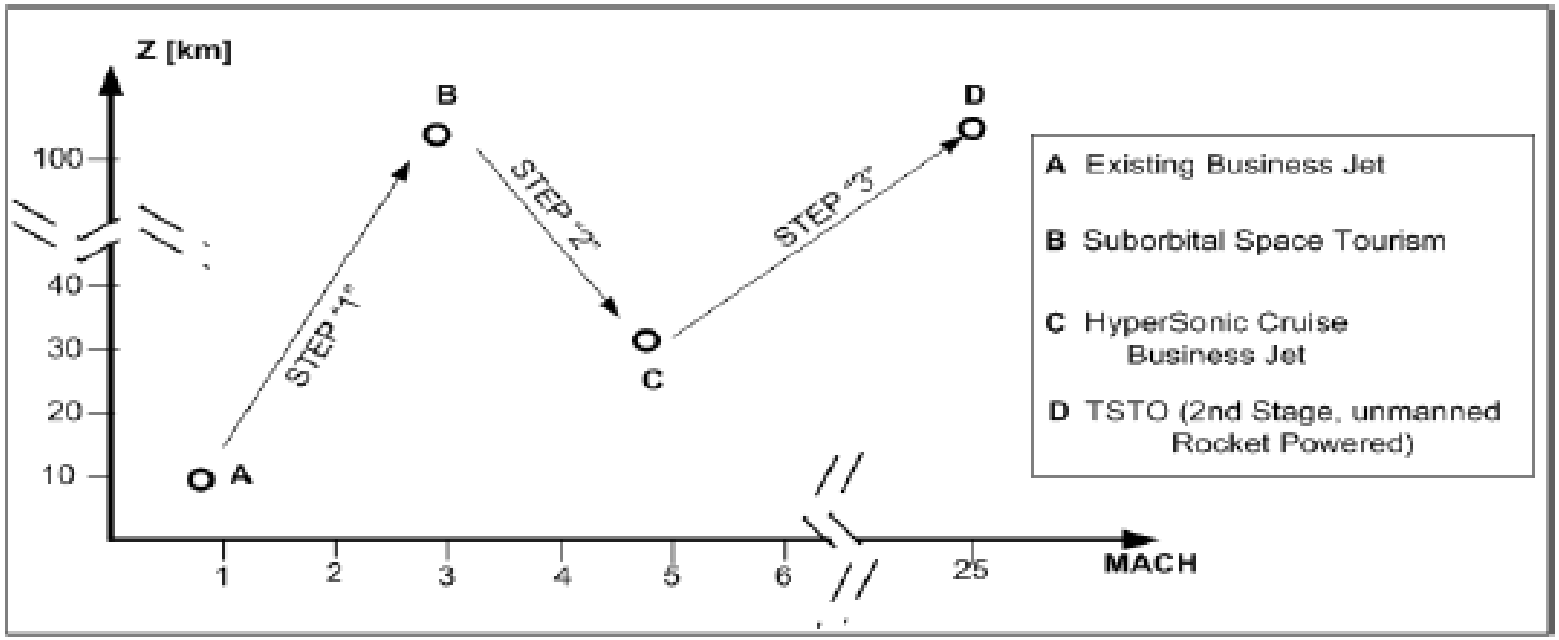
ZEHST configuration and Vehicle characteristics



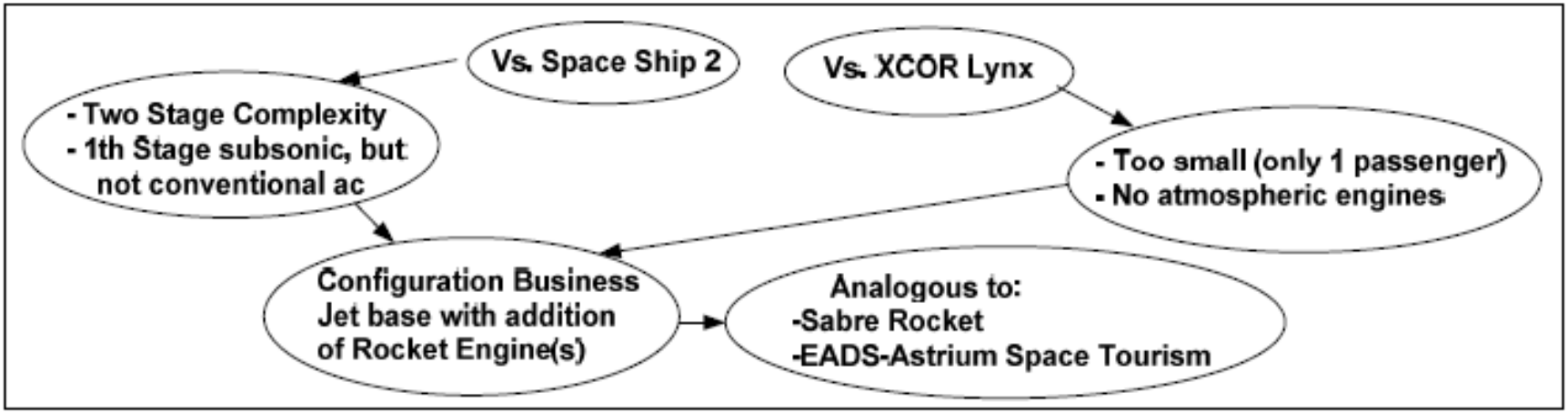
Space Tourism EADS; pictorial view and passengers cabin layout mock-up

- Sub-Orbital Space Tourism
- Passenger cabin layout

POSSIBLE ROAD MAP TO CONTRIBUTE TO DEVELOP HYPERSONIC FLIGHT



Roadmap for Hypersonic Flight development

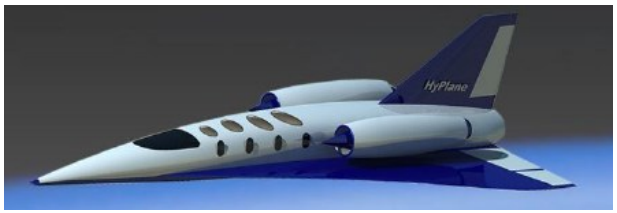


Proposed Roadmap STEP 1

Reference Business Jet		
Sub-orbital Space Tourism		1 Empty Weight increased because of the Rock 2 Rocket Propellant added 3 Pay Load reduced
HyperSonic cruise Business Jet		1 Empty Weight increased because of the Ram Jets 2 Fuel for HyperSonic cruise added 3 Pay Load as in "reference Business Jet"
Small orbital transport / RL		1 Empty Weight little reduced as no passengers 2 Fuel/Propellant only to reach separation point 3 Small Pay Load to/from Orbit

Empty Weight Fuel/Propellants Pay Load

Proposed Roadmap, STEPS 1, 2, 3



Hypersonic ? …
Why not ?